

"Electronics World", February 2011, pages 28-31

Comments to [ivorcatt@live.co.uk](mailto:ivorcatt@live.co.uk)

To read comments, go to [www.ivorcatt.org/x11x.htm](http://www.ivorcatt.org/x11x.htm)

## THEORY

# The End of Electric Charge and ELECTRIC CURRENT as We Know Them – Part 2

**Ivor Catt**, an engineer and a scientist, presents a two-part article on the matters of electrical charge and current. This is the second part

**"IT DOESN'T MAKE** any difference how smart you are, who made the guess, or what his name is – if it disagrees with real-life results, it is wrong. That's all there is to it!" Richard Feynman, Nobel Prize winner.

"...Scientists tend not to ask themselves questions until they see the rudiments of an answer in their minds. Embarrassing questions tend to remain unasked or, if asked, to be answered rudely." – P B Medawar, "The Future of Man" [BBC Reith Lectures 1959], pub. Basic Books Inc., N.Y., 1960, p62.

Last month, a narrow voltage spike was injected into a printed circuit conductor above a ground plane (**Figure 1**) in the presence of a parallel passive line (**Figure 2**). Further down the lines, it separated out into the faster Odd Mode and the slower Even Mode. Last month, I proved mathematically that the earliest, first traces were not permissible under Faraday's Law.

### Does Mathematics Distinguish Between Cause and Effect?

Electromagnetic theory grew out of the perusal of such things as magnets, electrically-charged bodies and the rest. This led to such concepts

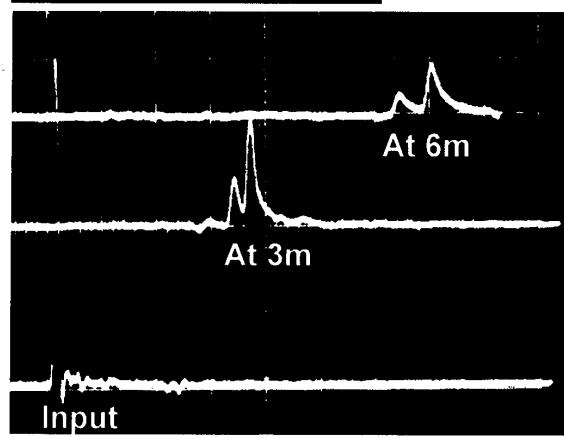
as electric charge and electric current, and to static electric field and static magnetic field. Faraday (thought he) discovered that a slowly changing magnetic field generated electric current. Much later, dubious mathematics was applied to such steady state things by Maxwell, extending to slowly changing fields, "electric currents" and, thence, to displacement current. According to Heaviside, displacement current derived from theoretical problems with the way electric current through a capacitor caused magnetic field.

Maxwell's invention of displacement current led to the idea that sunlight was electromagnetic. (Incidentally, my article "Displacement Current" in Wireless World, December 1978, pointed out that Maxwell and all lecturers and textbook writers up to today, overlook the electric current spreading out across the capacitor plates, which throws into question the reasoning leading to displacement current.)

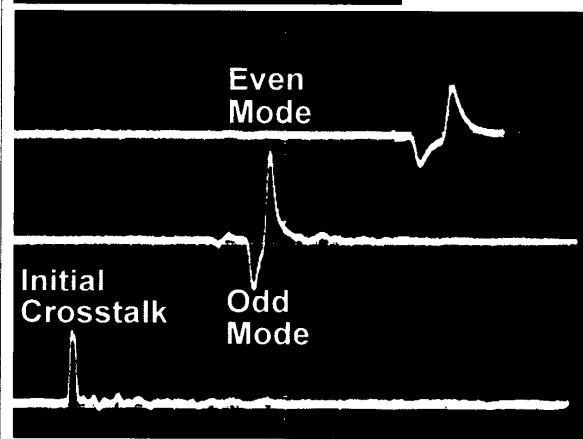
During this development of electromagnetic theory, there were no rapidly changing fields and no electromagnetism travelling very fast, at the speed of light. Later, in around 1880, Oliver Heaviside first addressed fast travelling electromagnetism in a sophisticated way.

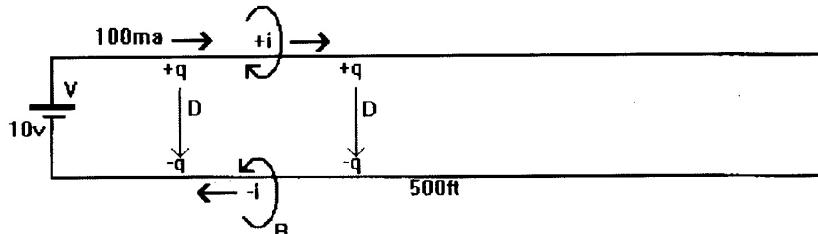
Maxwell started with magnets, electrically charged bodies and the like,

**Figure 1:** Signal on active left surface line



**Figure 2:** Signal on passive right surface line





**Figure 3:** Features of a voltage step travelling from battery to resistor

then much mathematical manipulation led to the Transverse Electromagnetic (TEM) Wave and light.

Now, supposing that we had started with sunlight, which we have always known about, instead of with static fields and devices such as magnets. Had we had the appropriate instruments, we would have found out that light was two-dimensional energy density and travelled in the third dimension at the speed of light.

Now, all this mathematical manipulation starting from electricity and fields and leading to light is reversible, since mathematics ignores causality and direction, in its equations. It is strange that the softer subject – chemistry – uses the more rigorous arrow in place of the ambiguous ‘equals’ sign used in our subject.

Since we know about sunlight, it is equally legitimate to start with sunlight or the TEM Wave (which sunlight is), and work backwards using the same mathematics towards electric field, magnetic field, electric charge and electric current. Only a historical accident caused us to progress in the traditional direction.

If we accept Occam's Razor, each of the items we then derive mathematically has to justify its existence as physically real, rather than merely the results of mathematical manipulation of things which are physically real. It turns out that, in electromagnetic theory, electric charge and electric current remain merely mathematical manipulations of what went before from our starting point with light, or the TEM Wave.

In the case of a battery connected by two wires to a resistor or lamp, they have no function. This is proved by “The Catt Question” (Electronics World, May 2009, p16) because of the dubious, contradictory “answers”

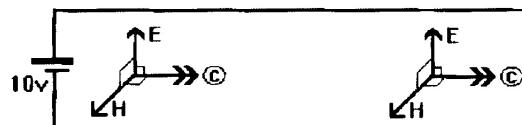
by leading experts over where the charge comes from. We see that electricity is not fit for purpose, not quick enough to do the job in hand. This can only be done by the original sunlight, or TEM Wave, which has the necessary speed to get the energy from battery to lamp, since it travels at the speed of light, which an electron cannot do.

Although a cloud cannot exist without edges, the edges of a cloud do not exist. They have no width, volume, mass or materiality. However, the edges of a cloud can be drawn. Their shapes can be manipulated graphically and mathematically. The same is true of the so-called “electric charge” and “electric current”. Maxwell's Equations show us that they are always on the edge of an electric or magnetic field. It was the alleged mass of electric charge which put it on a collision course with “The Catt Question”.

I excluded electric charge and electric current in 1976 and published “The Death of Electric Current” in Wireless World in December 1980. I relegated them to merely being mathematical manipulations of the electric field and magnetic field (or more accurately, of the electromagnetic field). There is a difference. For instance, the gradient in electric field density (which equals electric charge) does not have mass, whereas electric charge does have.

#### Concept of ‘Electricity’

It is pretty clear that the concept of “electricity” as perceived today started its life in the above role, of helping a battery to heat a resistor or light a lamp. Rubbing a glass rod with cat's fur played a subsidiary role in the origins of electricity. What are the other, surviving roles for electricity in today's science? I can think of the Bohr atom, the cathode ray tube and the diode.

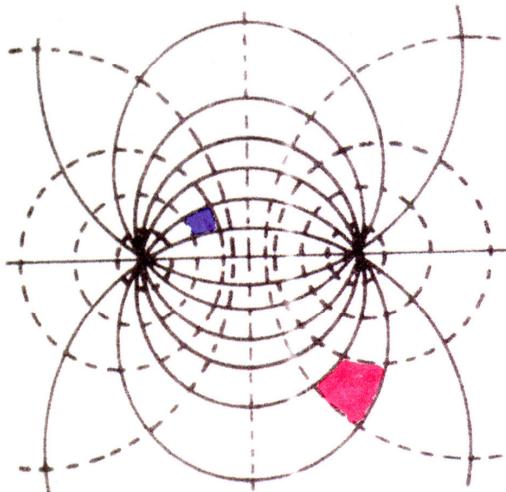


**Figure 4:** Features of a voltage step travelling from battery to resistor

E, B move forward  
with velocity C,  
velocity of light

## THEORY

**Figure 5:** Curvilinear Squares for a TEM Wave travelling between parallel lines, identical for other electromagnetic fields



**The Bohr atom:** Part of its role is to supply the "electrons" which expedite the flow of "electricity" from battery to lamp. But this role is discredited by "The Catt Question" and by the earliest, first traces in Figures 1 and 2, and all the traces in Figures 5 and 6 in the last month's article (Part 1). We see that electrons hop along from atom to atom down the passive wire in both directions at once, passing each other on their journey. However, surely other roles remain today for the "electrons".

**The Cathode Ray Tube:** First, a digression. I asked my co-author, the late Dr Arnold Lynch, why he was chosen to give the keynote speech in the IEE (now IET) to celebrate the centenary of J J Thomson's discovery of the electron. He replied: "Because JJ told me about it."

**The "electron",** with its debilitating mass, which prevents it from keeping up with a TEM Wave, is only one hundred years old. Now in Heaviside's "Energy Current" approach to electromagnetic theory, the energy current, or TEM Wave, delivered at the speed of light by the HT power supply, approaches the CRT sideways between anode and cathode, or in the case of the signal input, between grid and cathode. The movement is at right angles to the alleged movement of the electron. Now the interaction between the TEM Wave arriving as "HT" and the TEM Wave arriving as "signal" is complex. However, since they collide at 180 degrees, their collision should be handled to some degree by the discussion in my

1995 book. However, the detail still has to be worked out.

When we address the electron, apparently travelling in the wrong direction at the wrong speed, it is useful to consider a wave in the sea approaching us. White foam on top of the wave appears to travel at a lower speed at right angles to the approaching wave.

**The Diode:** The TEM Wave of Energy Current enters sideways, directly into the interface between the P region and the N region. "The diode as an energy-controlled, not a charge-controlled, device" is discussed in Electronics and Wireless World, September 1983, p903 and in my 1995 book.

### Tradition

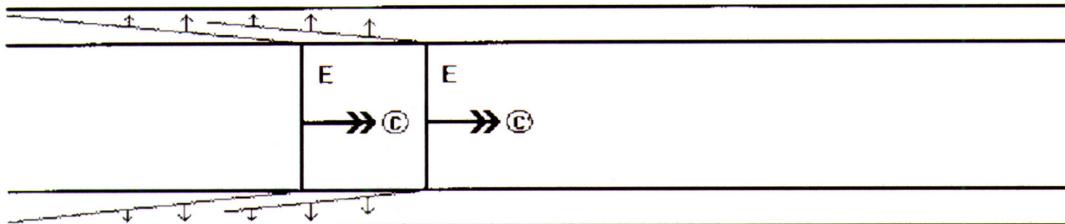
In case it should be feared that the transition described above moves us from a secure foundation to uncertainty, an analysis of the slovenly way in which the journey from "electricity" and fields to the TEM Wave and light was made, is called for. This is to be found in my articles "Maxwell's Equations Revisited" (Wireless World, March 1980) and "The Hidden Message in Maxwell's Equations" (Electronics & Wireless World, November 1985). My article "The Heaviside Signal" (Wireless World, July 1979) discusses how academia cleave to two mutually contradictory versions of the TEM Wave (or light), mostly, with Einstein, keeping to the false "Rolling Wave", where E causes H causes E. The flaw in "The Rolling Wave" is concealed by general ignorance about the relative phases of E and H, which is not mentioned in text books. If we accept the truth, that they are in phase, "The Rolling Wave" collapses. E and H cannot cause each other if they are in phase.

### The Figures

**Figures 3 and 4** show a TEM Wave's four features: i, q, E and H. Figures 1 and 2 here, and Figures 3 through 8 last month, only proved the existence of E, and we deduced H, (or B), but wrong to give physical reality to i and q.

These conventional concepts broke down in the case of the earliest, bottom trace in Figure 2, the right-hand passive conductor. Here, Even and Odd Mode spikes were superposed, so opposite electric currents flowed through each other and there were both positive and negative charges together on the surface of the conductor, each terminating its own independent electric flux. At the least, electric charge and electric current have to be redefined. Preferably they need to be removed from electromagnetic theory. As Maxwell's Equations show, they are the result of mathematical manipulation of electric and magnetic field, for instance  $\nabla \cdot \mathbf{D} = \rho_f$ .

**Figure 6:** A TEM Step travelling between parallel lines



The link between electric charge and electric field is the easiest to see. If electric field comes to an abrupt stop, the edge is called "electric charge". The ExH in the **Figure 6** penetrates into the conductors as well as advancing to the right. However, the dielectric constant of a conductor approaches infinity, which means that the velocity of penetration approaches zero, leading to a sharp edge in the electric field, which we traditionally call "electric charge".

Why can a TEM Wave (Energy Current) only travel in a balanced mode, Even or Odd, when guided by four conductors? The answer lies buried in the concept of "Curvilinear Squares", **Figure 5**. This single, extremely important field pattern, which applies to many situations in electromagnetism, was only drawn in one text book during the 20th century, presumably because the other authors and lecturers did not know it. When energy travels at the speed of light guided by two conductors, the same amount of energy travels through the red square and the blue square. The impedance of each square is 377 ohms if the dielectric is vacuum, or air.

It is best to think of the two conductors in Figure 6 as flat. As a wafer of energy current, like the voltage spike in Figures 1 and 2, travels along at the speed of light, it does not know what is ahead of it or behind it. It sees ahead not only the space shown ahead, but also the new segment of conductors to its left and right, where a 377 ohm rectangle (very long and thin because of the copper's great permittivity) will receive the same amount of energy as a small square ahead, this energy moving sideways into the conductors very slowly. However, since a square (of copper) has a very high permittivity and therefore very low  $Z_0$ , each 377 ohm rectangle must be elongated into a very long rectangle. Now because the velocity of the energy current is slower in the copper, the distance advanced to left and right into the copper is far smaller than the distance travelled forwards.

The angle of the sloping lines reduces towards horizontal as the permittivity is increased and, therefore, as the velocity into the copper reduces. As we approach the infinite permittivity of copper, the sloping lines become horizontal and we have a right angle between the forward travelling energy current and the surface of the conductor. This probably explains why a stable TEM Wave guided by four conductors must have its curvilinear squares, (or its electric field) at right angles to the surface of the conductor, limiting the permissible wave fronts guided by our four conductors to Even Mode and Odd Mode, which are the only possible wave fronts which are symmetrical.

#### Einstein's Error

*"The special theory of relativity owes its origin to Maxwell's equations of the electromagnetic field."* – Einstein.

The observed and photographed phenomenon, Figures 1 and 2, and Figures 5 and 6 from last month, contradicts the starting point of Einstein's theory of relativity.

In Figures 1 and 2 the spikes continue unchanged (after first separating out). When discussing the origins of Relativity, Einstein dismissed such a possibility as absurd: "... If I pursue a beam of light with the velocity c (velocity of light in a vacuum), I should observe such a beam of light as a spatially oscillatory electromagnetic field at rest. However, there seems to be no such thing, either on the basis of experience or according to Maxwell's equations."

Now in Figures 1 and 2 the spike could be a brief flash of monochromatic, sinusoidal light travelling between the two conductors,

unchanged, just like the spike. In trace 2, then 1, each spike appears as a "spatially oscillatory electromagnetic field at rest [unchanging]", which Einstein dismisses as absurd.

Notice that in addition to my observing and photographing such a "spatially oscillatory electromagnetic field at rest", my calculations towards the same conclusion last month were based only on Maxwell's equations. Of course, Einstein never used a high-speed sampling oscilloscope. It is less clear why he avoided the imperatives of Maxwell's equations.

Einstein teaches 'The Rolling Wave'; the idea that in a TEM Wave E causes H causes E, which breaks down for each spike in Figures 1 and 2 (see Albert Einstein and Leopold Infeld's 'The Evolution of Physics') where it is written: "...What kind of changes are now spreading in the case of an electromagnetic wave? Just the changes of an electromagnetic field! Every change of an electric field produces a magnetic field; every change of this magnetic field produces an electric field; every change of ..., and so on. As field represents energy, all these changes spreading out in space, with a definite velocity, produce a wave. The electric and magnetic lines of force always lie, as deduced from the theory, on planes perpendicular to the direction of propagation. The wave produced is, therefore, transverse."

In contrast, on page 6 of volume 3 of his "Electromagnetic Theory", Heaviside stands firmly for "The Heaviside Signal". For instance he says: "...the whole slab moves bodily to the right at speed v, .... It carries all its properties with it unchanged," which is a clear statement of the Heaviside signal. He mentions the slab elsewhere in his writings. One does not conceive of slabs rolling, or of one part of the slab causing another part. Almost by definition, a slab, like a slab of heavy granite, moves forward unchanged at constant velocity, like Figures 1 and 2.

#### Blindness

We can learn a lot from my failure to notice the key point of this article for 43 years. When I published my article in 1967 I was excited about the fact that in the case of crosstalk (interference) between two parallel conductors, two velocities were involved, which was not previously known, and that crosstalk could reach 50% however far apart they were separated. This caused me to overlook the historic point discussed in this two part article.

However, there was a much more important reason for my failing to see the obvious. This was that I was socialised into respecting the reigning theory, along with its mathematical baggage. I was also impressed by the mathematical clutter that I created, reproduced last month. Thus, when I showed that only two modes were legitimate, it did not occur to me that the obvious third mode seen in the earliest trace in Figures 1 and 2 contradicted the limit of two modes deduced by the mathematics. Given my conventional education, there was no possibility that I would notice that the mathematics, and with it Faraday's Law, were being disproved before my eyes.

But did Figures 1 and 2 contradict the mathematics as well as contradicting Faraday's Law? Here we see how inadequate mathematics is as a language, because it is indifferent to questions of superposition and so was neither proved nor disproved by the photographs. Mathematics is indifferent to many other features of the physical world. This is why today's hijacking of the physical world by the limitations of mere mathematical analysis is disastrous.

If you missed Part 1 of this article you can now order it by going online at [www.electronicsworld.co.uk](http://www.electronicsworld.co.uk)

Advice on reading this article is at <http://www.ivorcatt.co.uk/x111.htm>

This article develops from my 1967 article "Crosstalk (Noise) in Digital Systems"

<http://www.ivorcatt.co.uk/xy.htm> where you also get access to the articles cited in this article.